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Emergent Workflow: The AIS Workware Demonstrator

negaprograms module/workflow automation / COMPONENT DEF. / MANIFOLD
Nierstrasz / VISTA
Dabke / NetBuilder

Steinar Carlsen and Håvard D. Jørgensen

SINTEF Telecom and Informatics, P.O. Box 124 Blindern, N-0314 Oslo, Norway

Abstract: We describe a prototype cooperation support system incorporating adaptive workflow currently being developed in the AIS project. A workware system that includes task management and adaptive workflow support, available through a simple web browser user interface, is being prototyped. Our primary objective is to support the dynamic and ad-hoc work that is becoming increasingly important in today's knowledge intensive organizations. We cover unstructured and partly structured representations of work, and allow dynamic modification of workflows during performance. The proposed architecture is highly tailorable, allowing users to add and interconnect new tools and information types. This paper is also available in the PDF-format.

1. The Adaptive Workflow Challenge

We view workflow as active support for planning, performance and coordination of work that is based upon a (more or less complete) explicit process model. In line with (Miers 1996), we primarily are interested in workflow allowing for coordination through mutual adjustment in creating, adapting, combining and linking process model fragments.

Empowerment with respect to workflow process models and their encoded behavior implies an ability to browse available organizational actions and to create one's own libraries of actions to invoke when they are found suitable (Carlsen and Gjersvik 1997a), resembling advisory process models (Abbot and Sarin 1994). It is also related to layered policies in business process definitions as in Obligations (Bogia and Kaplan 1995) and to an organizational handbook of business processes (Malone, et al. 1997).

AIS partners' background includes CSCW, IS conceptual modeling, enterprise modeling, and intranetworking a global enterprise. AIS is an ongoing project in which we address adaptive workflow as one component in a wider intranet-based cooperation setting. The project will build and experiment with prototypes to advice future implementation and deployment.

AIS is an acronym in Norwegian for Avansert Intranett Samarbeid (Advanced Intranet Collaboration). The project is sponsored by the Norwegian Research Council and the project partners are Det Norske Veritas, NCR Metis, Saga Petroleum, FAFO (Institute of Applied Social Science) and SINTEF Telecom and Informatics.

2. The AIS Workware Approach to Adaptive Workflow

The AIS Workware Demonstrator (AWD) should be useful for an autonomous workgroup and features provided should be relevant for "normal" end-users, not only for a process-modeling priesthood. We focus on the integrated planning and performance of work, thus mutable process models and enactment support for unfinished process models are vital. We assume an available information-sharing infrastructure, thus process models primarily reflect *flow of work*, not flow of "documents" (Abbot, et al. 1994). We consider this important also for reduction of process model complexity, our models offer the possibility of capturing information access through shared workspaces, thus limiting descriptions of detailed information flow. Finally, in realization of the prototype we focus on workflow *instances* first; at later stages we will cover process model templates, repositories and a stronger link to knowledge management and our enterprise modeling background. Thus, since each workflow is unique and situated, we treat exceptions as the rule of the game.

2.1 Conceptual Design

Avoiding unnecessary classification, the most basic concept in AWD is that of a *work item*, which intentionally, and dependent on its life-cycle, may correspond to both a process and a task in contemporary workflow systems. Work items are available from a *worklist tool*, which may present all work items belonging to a project or only the work items currently allocated to a particular (role-playing) person. Work items are presented through their "job top"; presumably inside a web-client with links to relevant resources. Through this user-interface we present three types of *work item services*:

- **Planning services**, which conform to articulation work (Bannon and Schmidt 1989; Schmidt and Simone 1996; Suchman 1987), including process modeling and editing.
- **Performing services**, which provide access to the necessary tools and information objects for performing work.
- **Coordination services**, which correspond to changing the work item state, e.g. marking a work item as finished, thus progressing work in accordance with process models.

Work items may be composite, i.e. contain sub work items. For an "atomic" work item, the default interpretation is that the responsible actor may or may not choose to supply a decomposition. Composite work items span from *work item collections*, which only have an unordered list of components, to *workflows* where component work items are interconnected.

In the life-cycle of a work item, a composition might be supplied corresponding to responsible actors planning their own work; a composition might be changed or removed corresponding to re-planning; or work may become reported as performed corresponding to ignoring an available plan for performance. We will capture process model history in an extended process instance audit-trail.

Work items require resources like (role-playing) actors, information objects and tools. Contrasting WfMC terminology (WfMC 1997), we do not distinguish sharp between *invoked* and *available* applications; traditional invoked applications and their initialization might be achieved through performing services.

Finally, work items have *external properties* with respect to their encompassing process model. These consist of the *resource signature*, corresponding to resource requirements above, and the *external interface* describing input and output flows, possibly grouped through ports. In general, we leave decomposition to the discretion of the performing actor(s) as long as the external properties remain unchanged; cf. section 2.2 *Process Modeling*.

Work item *services* correspond to commands the user can invoke on the work item. They are work steps so fine-grained that we do not represent them as a work item itself. Classification into planning, performing and coordination services primarily is suitable for grouping available commands in the user interface; the same service may be used for both planning, performing and coordination in different contexts, i.e. for different work items. For instance, we may have a work item where performance actually corresponds to planning future work. Services may be configured through an available system service; users may add, remove or compose new services. We plan to provide some general services as part of every configuration, in addition we will support configuration templates for work item subclasses, and let users maintain their own libraries of work item templates with corresponding services.

For the realization of the prototype, we focus on platform independence based on standards and desktop integration through helper applications in web-browsers, internet mail-clients etc. We focus on extendibility where the addition of new tools/services is easily achieved through customization services. AWD currently is implemented using Java servlets, http and html, and we investigate the use of XML for all internal data representation - worklist items, process models and audit trails.

2.2 Process Modeling

Conventional process modeling languages have a suitable graphical depiction supporting decomposition, a preferred procedural conceptualization and they are relatively well-known. In AIS we want to provide continuity in conceptual modeling methods and techniques.

Action Port Model (APM; (Carlsen 1997; Carlsen 1998)) is based on the conceptual modeling languages PPM (Gulla, et al. 1991; Willumsen, et al. 1993) and a corresponding experimental CASE-tool which allows for executable conceptual models. PPM process models are extended data flow diagrams (Gane and Sarson 1979). PPM process models reflect information system processes, while APM process models reflect work processes. Their foci are different but complementary. APM through its PPM heritage takes a traditional transformational (i.e. IPO ö Input Process Output) view as a starting point, extended with:

- *Resource modeling*: covering organizational actors including roles, software resources as invoked or available applications, available information objects and other process definitions as pluggable elements.
- *Templates*. APM facilitates the use of *templates* and *clichés* as process model building blocks. A template is a (possibly incomplete) model taken as a starting point for adaptation. Clichés capture commonly used interaction patterns found across several concrete work processes.
- *Interaction modeling*, inspired by speech act modeling and role interactions.
- *A unified approach to actors and actions*. In APM interactions, component actions capture exchange of speech acts and represent both the actor and the action itself.
- *Shared workspaces*. Information supply can be reflected as information object resources, simplifying process models by limiting superfluous information flow.

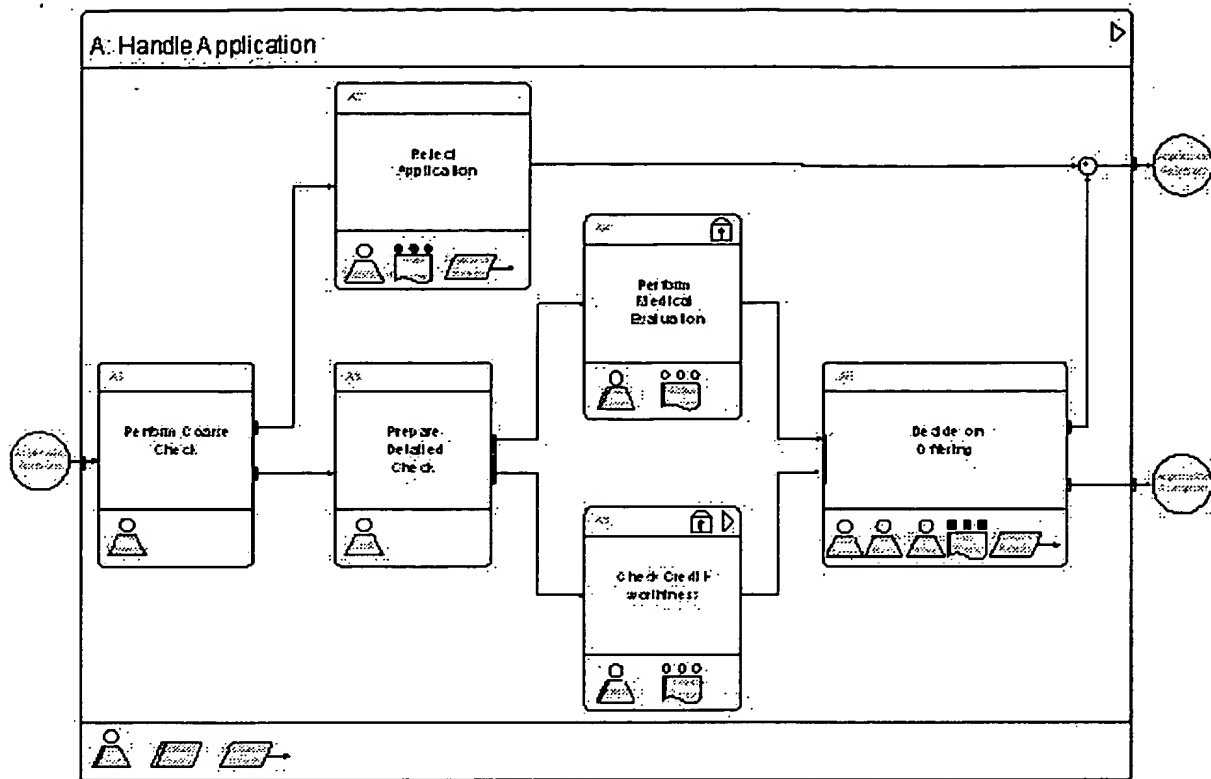


Figure 1: APM action with decomposition

APM processes are connected series of organizational actions, of which some may be composite; i.e. have a decomposition into a process containing sub-actions. An action represents work to be performed by its actors utilizing other resources; typically tools and information objects. Actions have external properties given by their interface and resource signature. Interfaces are described through a port mechanism consisting of mutually exclusive input and output ports, each denoting a conjunction of flows, while the resource signature lists resources with type. Composite actions have a decomposition, i.e. definition as a process consisting of lower-level actions. Elementary actions currently have no specified decomposition; i.e. the decision of a possible further decomposition is postponed and left the judgment of the performing actors. Operationally, APM process models are considered resources for situated action (Suchman 1987; Bogia, et al. 1995; Bardram 1997); they are socially constructed artifacts forming the basis for performance by involved actors using specified resources; the definition is considered as a guide that may mutate to cover unforeseen events and exceptions.

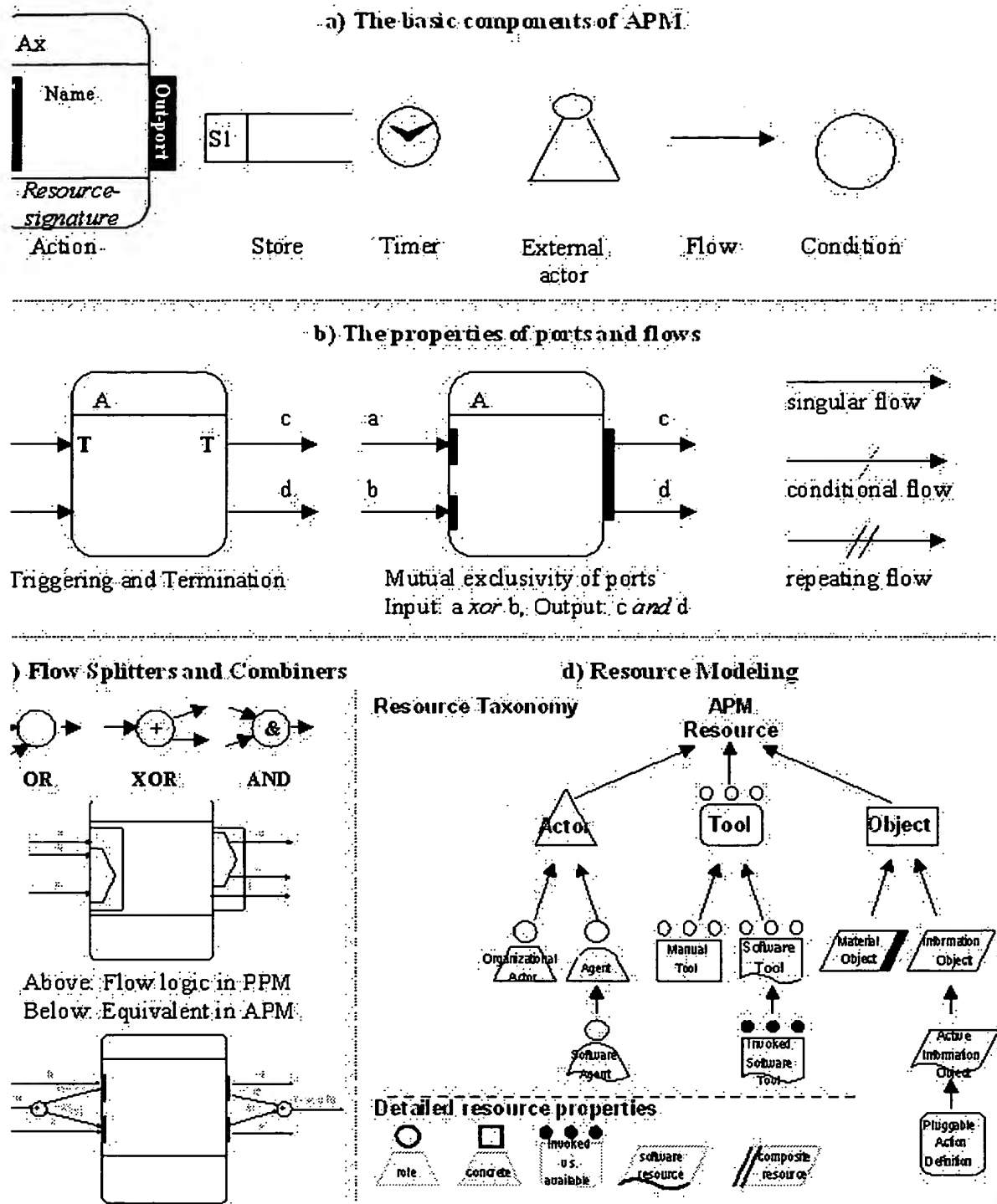


Figure 2: APM's modeling constructs

Figure 1 shows an example composite APM action, *Handle Application*, with its decomposition. *Handle Application* will be performed by a composite organizational role called *Case Team* having access to a composite information object *Applicant Folder* and produces the information object *Application Results*. *Handle Application* has a single

input port and two mutually exclusive output ports. Flows in this example all correspond to *signals*; i.e. they do not carry any information. The circles are APM *conditions* that correspond to some predicate or statement being true.

Figure 2 shows the basic modeling constructs of APM: *Actions, Stores, Timers, External actors, Conditions, Flows, Ports, Flow combinations* and *Resources*. In addition, we have a notation for capturing interaction between process actors, based on the exchange of speech-acts (Dietz and Widdershoven 1992; Winograd 1987). At the process model level, we capture actions that are *interactions* which, through decomposition, might embed other actions. At the process support level, interaction support will be provided through an integrated conversation support system. More details on the APM language can be found in (Carlsen 1998).

Process modeling in AIS Workware will be based on a scaled-down and adapted version of APM. Adaptation of APM is needed to align it with Metis modeling languages (Brathaug and Evjen 1996), and we may provide a more end-user oriented graphical depiction.

APM's parent language PPM provides executable IS conceptual models. AWD enactment support will be based on a state transition model for work items, resource provision through a *resource broker*, external interfaces of work items and the interpretation of coordination events brought forward by the coordination services. As we also would like to provide opportunistic work item involvement, we will experiment with the integration of an awareness service and allow *fallback* through asking users for advice whenever the enactment service itself is unable to deduce unambiguously the next steps.

2.3 Process Knowledge Management

When planning or re-planning work items by creating or adapting process models as part of the ongoing articulation work, people create knowledge, of which some is externalized in the situated process models. This knowledge typically must be combined and linked with existing knowledge and finally, through harvesting, may be mobilized for future reuse. We may say that process models constitute an arena for *knowledge creation* (Nonaka 1994). In AIS a knowledge management perspective is explicitly addressed through the constructive composition (Langefors 1973) of models from parts, where we provide a rich, mixed-ontology graphical language for knowledge externalization. Knowledge *combination* is further enhanced by supporting model templates available from repositories as a basis for model composition. We approach knowledge *harvesting* through a proposed way of gaining experience from past models to update template repositories; cf. Figure 4.

To integrate the enterprise modeling and adaptive workflow perspectives at the process instance level, we have been working on a process

modeling reference-model as shown in Figure 3.

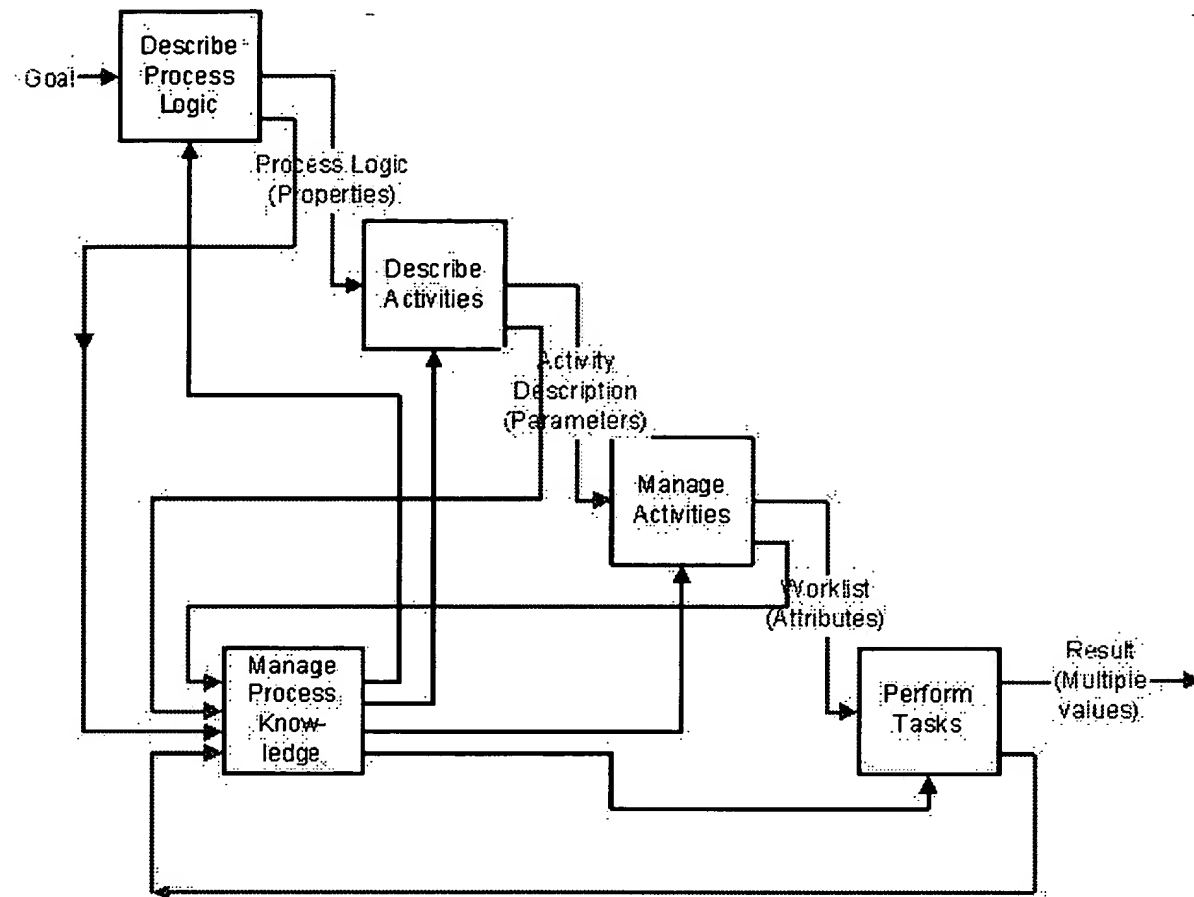


Figure 3: Process modeling reference model

Level 1 – Describe Process Logic

At this level, we identify the constituent activities of a generic, repetitive process and the logical connections between components. The model at this level should be transferable across time and space to a mixture of execution environments. At this level we find descriptions of conceptual value chains and normative descriptions of ways of working for particular organizations. Traditional IPO process models like dataflow diagrams have a suitable conceptual vocabulary; Metis currently de-ploys the *Flowlogic* language based on *IDEFO*. *Use Case models* (Jacobson, et al. 1994; Jacobson 1993) may also be suitable, but perhaps somewhat insufficient regarding a variety of logical relations (beyond *uses* and *extends*). Declarative, constraint-based descriptions like *Freeflow* (Dourish, et al. 1996), also seem suitable, though they are currently targeted at the enactment level.

Level 2 – Describe Activities

Here process models are expanded and elaborated to sufficiently cover realization. Elaboration covers concretization, decomposition and specialization. This includes assigning abstract resources needed for

actual performance. Thus, reasons for dependencies between the subactivities of a plan to a larger degree are uncovered. Often planning of work actually starts at this level, but can be abstracted to the level above. APM using abstract resources, Metisâ ICOM language (Input, Control, Output, Mechanism; Brathaug, et al. 1996), and RAD (Role Activity Diagram; Ould 1995) are all candidate modeling languages at this level.

Level 3 ö Manage Activities

Here more detailed decisions are taken regarding the performance of work in the actual work environment with its organizational, informational and tool resources; the scope is narrowed down to an actual process instance. Concrete resources increasingly are intertwined in the model, leading to the introduction of more dependencies between tasks. Management of activities may be said to consist of resource bindings and coordination; i.e. the binding of abstract resources to the actual concrete resources of the enactment environment and the management of information related to the shaping of activities and their actual performance necessary for coordination with related activities. APM, with its coverage of resource signatures and resource bindings is suitable at this level.

Level 4 ö Perform Tasks

This lowest level of our reference model covers the actual execution of tasks according to the determined granularity of work breakdown, which in practice is coupled to empowerment and adaptive workflow issues. When the task is performed by a single organizational actor, whether to supply a further decomposition may be left to her discretion, or alternative candidate decompositions might be provided as advisory resources.

Management of Process Knowledge

In our context, we define knowledge management as the collection of processes necessary for innovation, dissemination and exploitation of (process) knowledge in a cooperating ensemble where knowledge seekers are linked to knowledge sources and a shared knowledge base is cultivated. Process knowledge management is active at all levels of our reference model. In particular, models of past process instances - typically situated at the lower levels of our reference model - may be subject to a harvesting process in order to update templates available at the higher levels. These updated templates then become resources for situated planning in the future. Thus there is an identified need of providing an integrated environment with tool support at all levels of our reference model, with particular tools specialized at their own level, integrated through a common process knowledge management approach.

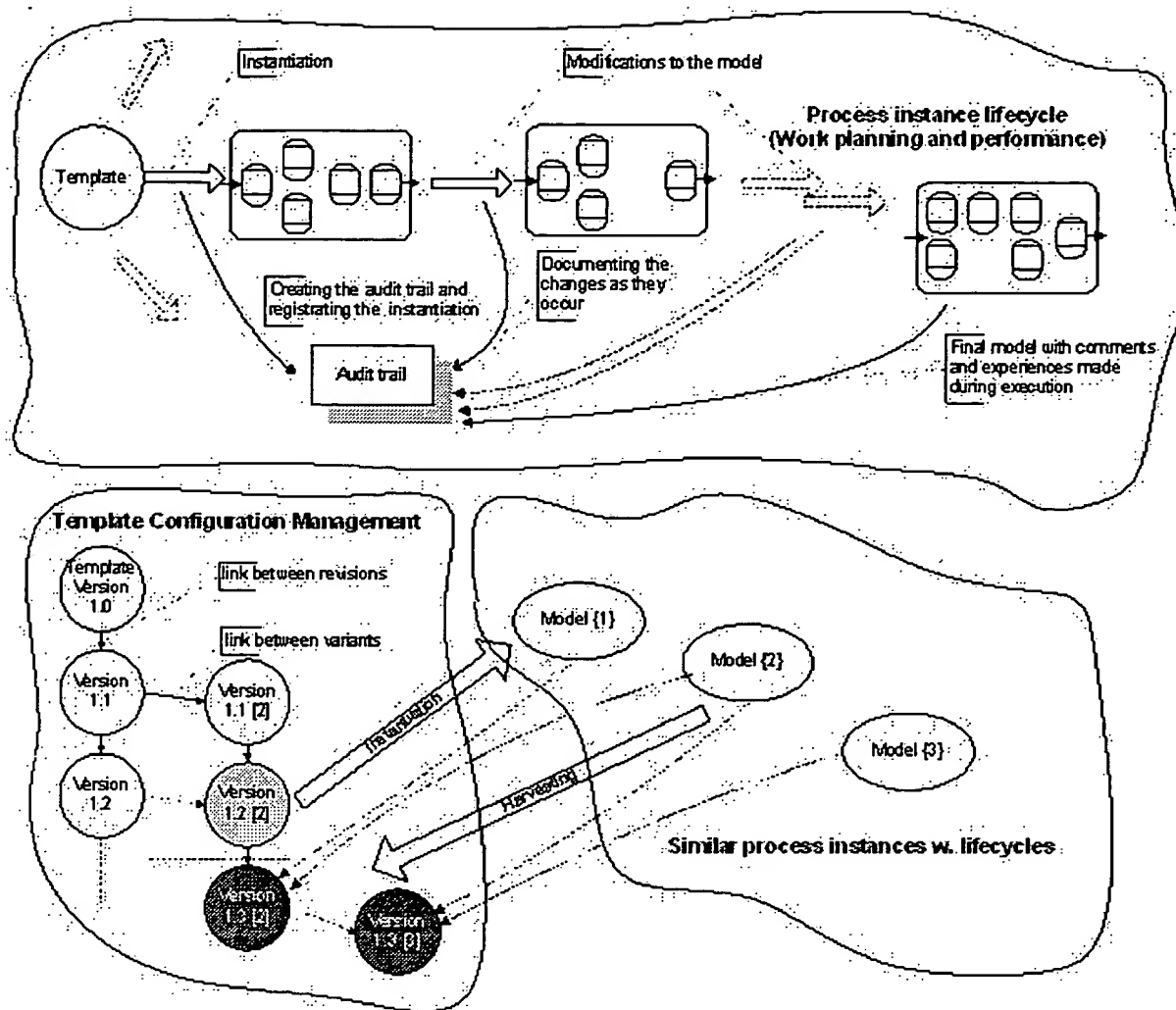


Figure 4: Harvesting experience from extended audit trails

3. Contributions

We link adaptive workflow with enterprise modeling, to create an integrated process support solution that spans from general business processes and organizational guidelines down to representations of work the way it is actually performed. This enables a down-to-earth approach to process *knowledge management*, through managing templates at several levels of abstraction and possibly in several revisions and variants.

Our proposals for modeling constructs represents *continuity* with respect to existing and traditional graphical modeling languages. Both representations of work and organizational knowledge management are major important research areas. Graphical, hierarchical, decomposable and constructive modeling languages founded on a formal basis, like APM, seems promising to join these two areas. In particular, APM takes a transformational view on processes, extended with *interaction*

modeling and *resource modeling* where shared workspaces and process models themselves are included as resources.

Recently, adaptive workflow approaches based on constraint reasoning have been proposed (Glance, et al. 1996; Dourish, et al. 1996). These approaches focus on carving out spaces of possible solution alternatives to process enactment through the explicit representation of *constraints* between various tasks, roles etc. Thus, problems with traditional process models and *over-serialization* are avoided, but these approaches may lead to incomprehensible models since they by nature are like statements in a programming language, where a graphic depiction is difficult since it would correspond to a visualization of several possible solutions to a set of constraint equations constituting the process model.

In our work, we focus on graphical explicit comprehensible models as a necessity for closing the gap between *flexible representation in adaptive workflow* and *knowledge management covering business and work processes*. We tie enterprise models made for a variety of stakeholders to workflow models intended to support autonomous groups who both plan and perform their own work, often coordinated through mutual adjustment. We link the perspective of unique process instances back to enterprise models covering standardized processes available as organizational resources.

4. Future work

We are attentive to (recent) workflow standardization efforts, like WfMC's Process Definition Interchange interface (WfMC 1997), the OMG jFlow proposal (OMG 1998) and the recent SWAP proposal (Swenson 1998), and to the extent possible and reasonable will align our work with these standards.

AIS Workware's potential for *high pragmatic quality* process models (Carlsen, et al. 1997b) is ensured through a preferred procedural conceptualization of processes in a semantically explicit graphical language where detailed information flow may be minimized assuming an information sharing infrastructure and hence capturing information objects as resources representing a shared workspace. The potential for pragmatic quality can be further enhanced by adapting existing *explanation generation* and *complexity reduction* facilities to APM via its parent languages PPP / PPM where this integration has been achieved (Gulla 1996; Seltveit 1996). This functionality, currently only found in experimental case tools with executable models, we think will be very important for the adaptive workflow community.

AWD's worklist is also the foundation for prototyping awareness services in a cooperation environment, focusing on asynchronous awareness where the various work items themselves collect and distribute events that may be of interest to a particular work item's

audience. Such event filtering, distribution and notification may be of importance for ad-hoc coordination in autonomous groups, and we also think it will be relevant for allowing opportunistic work item involvement, like in *Freeflow* (Dourish, et al. 1996).

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